

# Research Newsletter

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## A MESSAGE FROM THE RESEARCH DIRECTOR

By: Cameron Kergaye, PhD, PMP, PE

Every year TRB sends one of their Technical Activities Division program officers to visit and interact with UDOT's divisions. In early September we met Ms. Christine Gerencher, who coordinates TRB research projects relating to aviation and environment. The information exchange that took place covered both industry changes and recent research. Perhaps one of the most important highlights of the meeting was learning how to gain online access to TRB and NCHRP publications and TRB standing committees' Information Resource Centers.



Pat Morley of UDOT Aeronautics, Cameron Kergaye, and Christine Gerencher

Every UDOT employee accessing [www.trb.org](http://www.trb.org) from their office computer now has unlimited access to TRB and NCHRP publications, including the Transportation Research Record journal. User names and passwords will not be needed since our office computers will relate a pre-qualified domain. And for those receiving Joni DeMille's monthly list of library acquisitions, you will now find it easier to gain full electronic copies of TRB material.

UDOT will host their Annual Conference on November 5-7. Among the many informative breakout sessions, the Research Division will again host a research poster session to illustrate UDOT's innovative activities and research. This year the event will take place in the main exhibitor hall from 9:30 to 11:30 a.m. on Wednesday, November 6. Please stop by to learn what's new and innovative from our UDOT, consultant and university research partners.

Information about the Research Division and completed research reports and other funding sources can be found on the Research Division website: [www.udot.utah.gov/go/research](http://www.udot.utah.gov/go/research)

### In This Issue: (click on desired article, click on logo at top to return to this page)

IN THE FIELD: DUROMAXX AND ADS HDPE CULVERT DEFLECTIONS .....	2
LESSONS LEARNED —PAVEMENT MARKING WARRANTY CONTRACT .....	3
CORROSION EVALUATION OF STEEL PILES IN SLAG FILL .....	4
EXPLORING ARIZONA'S RECESSED PAVEMENT MARKERS .....	5
MORE FOR THE MONEY: COST-BASED ESTIMATES ARE HELPING UDOT DESIGN, ADVERTISE AND BUILD MORE EFFICIENTLY .....	6
CALENDAR OF EVENTS/UPDATES .....	7

Completed and Active Research Available at: [www.udot.utah.gov/go/research](http://www.udot.utah.gov/go/research)

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## In the Field: DuroMaxx and ADS HDPE Culvert Deflections

Several pipe options from various manufacturers are available to state highway agencies for drainage culverts below highways. UDOT hydraulic engineers are currently improving UDOT's pipe standard specifications and exploring new pipe products for certain applications. One example is a test section on Manhead Road in Rich County, Utah where in July 2010 a new HDPE drainage culvert utilizing a steel spiral rib was installed in one location on the road rehabilitation and widening project (see Fig. 1). The new pipe is called DuroMaxx and is made by CONTECH Construction Products, Inc. Most of the nearby new culverts on the project were conventional N-12 HDPE pipe manufactured by ADS Corporation. Some concrete pipe was also used for project culverts. Rich County representatives expressed interest in trying out the DuroMaxx pipe, and UDOT approved the non-standard pipe for use on the Federal aid project on a test and evaluation basis. Performance of the DuroMaxx pipe in this location would help UDOT judge its suitability for installation in other locations in Utah.



Fig. 1. DuroMaxx pipe installation.

Shortly after installation of the DuroMaxx pipe, UDOT contracted with Dr. Steven Folkman of the Utah State University (USU) Buried Structures Laboratory to monitor deflections in the DuroMaxx pipe for three years, along with some nearby ADS HDPE pipe for comparison. Both culvert types were 24 inches in diameter. In each monitored installation location, two pipes (either ADS or DuroMaxx) had been installed beside each other with an approximately 5-inch gap between them. Although photographs and other information made available to the researchers indicated both types of pipe had nearly identical installation procedures, the available documentation was insufficient to guarantee that the procedures were identical. The small gap between the monitored side-by-side pipes likely

reduced the ability of compaction equipment to work the backfill soil into the haunch regions.

Culvert deflections were measured and conditions were observed during five visits over a three year period. At each visit, the researchers crawled through the pipes and measured horizontal and vertical deflections with a Bosch distance sensor at multiple stations along the pipes (see Fig. 2). Low soil compaction in the pipe haunches and a small soil column between pipes resulted in larger deflections (up to 7% deflection) than expected in the ADS pipe but not enough to require replacement. In this situation the DuroMaxx pipe did produce smaller deflections (up to 3% deflection). With regard to pipe deflections, the DuroMaxx culverts have had excellent performance so far at this site.

According to Jerry Chaney, UDOT Senior Hydraulic Engineer, UDOT plans to use the DuroMaxx and ADS HDPE pipes on future projects. As UDOT's pipe standard specifications are improved, the hope is that pipe installation procedures will also improve so that the pipe type used can function as designed for the project.

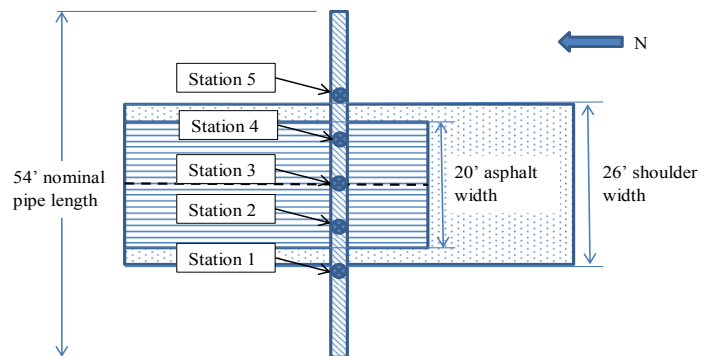


Fig. 2. Measurement stations along the pipes.

For more details on the DuroMaxx pipe monitoring, see the final report on the Research Division website, or contact Dr. Steven Folkman of USU at: [steven.folkman@usu.edu](mailto:steven.folkman@usu.edu), or the following UDOT study participants: Jerry Chaney ([jchaney@utah.gov](mailto:jchaney@utah.gov)) and David Stevens ([davidstevens@utah.gov](mailto:davidstevens@utah.gov)).



## Lessons Learned—Pavement Marking Warranty Contract

In 2012, UDOT implemented a performance-based warranty on portions of an I-15/I-215 pavement marking project. The awarded contract requested a contractor warranty on the implemented markings for a total duration of six years. This is the first time that UDOT has requested a warranty on pavement markings, and also the first time that Interstate Maintenance (IM) funds were used for pavement markings. Through this research, surveys of key involved UDOT personnel, reviews of pavement marking contracts, and reviews of experiences from other agencies have been performed in order to document lessons learned from all phases of the pavement marking warranty project.



Paint Striping Truck in Action

The contract requests from the constructor to maintain a minimum retroreflectivity of 200 mcd/m<sup>2</sup>/lux for white, and 125 mcd/m<sup>2</sup>/lux for yellow markings over the entire six-year warranty period. The estimated length of implemented markings is more than 2.23 million linear feet (approximately 423 miles), over the 17.4 miles of segments along I-15 and I-215. Based on the contract amount, the estimated cost per linear foot is \$1.77 in 2012 USD for the six years, or approximately \$0.30 per linear foot per year.

The survey results for the preconstruction, construction and post-construction phases of the I-15 pavement marking warranty contract show a high level of

agreement that this type of pavement marking contract is a better option than traditional, non-warranty contracts. Although some disadvantages were recognized (higher initial cost, a more complex bidding process, difficulties in risk assessment), the identified advantages (increase in safety and convenience for the traveling public, cost-benefit and life-cycle benefits, increased performance, protection against failures, reduced need for field inspections, relocation of the risk) significantly outweighed them.

The implemented performance-based pavement marking warranty project is seen as a huge success. Similar benefits, advantages, disadvantages and problems with this type of contracting are observed in this project as in similar projects implemented by other agencies. Some of the problems are recognized here, and they can be addressed in future implementations. Considering that this is still an innovative approach in pavement marking projects, it shows a lot of potential, and UDOT should choose this direction for large-scale pavement marking projects, as well as other construction projects where performances can be clearly identified and measured. These types of interstate freeway projects are also good candidates for FHWA's support, as well as additional funds obtained through the Utah Transportation Commission, since they satisfy both capital improvement and preventive maintenance requirements.

The pavement marking warranty project is in its initial phases, so there are still not enough data for a more detailed analysis and assessment. A similar study should be performed further down the life of the project, when more data on performance, pavement marking life, costs and benefits are available.

For more information, contact Russ Scovil ([rgscovil@utah.gov](mailto:rgscovil@utah.gov)) of UDOT's Research Division.

## Corrosion Evaluation of Steel Piles in Slag Fill

The Sam White overpass on the I-15 alignment near American Fork, Utah received considerable attention during its reconstruction on the I-15 CORE project in 2011 (see the [UDOT blog](#)). The large national interest in the reconstructed bridge structure was due to its being the longest two-span bridge ever built offsite and moved into place in the Western Hemisphere at 354 feet long.

Another interesting fact about the Sam White overpass site is that Dr. Kyle Rollins of Brigham Young University began a study in 2010 to evaluate the corrosion rate of steel piles at the former overpass structure's west abutment. The old piles in this location had been partially supported by embankment fill consisting of slag for 48 years. Significant volumes of slag from Geneva Steel were to be used as construction fill material on the I-15 CORE project through Utah County. Many UDOT engineers had concerns about the slag material causing excessive corrosion of steel piles supporting the new bridge structures. Ultimately no slag was used next to bridge piles on the project, but it was used for some embankment fills.

The old abutment pile foundations were about 50 feet long and consisted of a combination of battered and vertical piles. Original design drawings indicated the piles were to consist of a steel shell (#7 gauge or thicker) with a minimum diameter of 12 inches. The old piles had been driven closed-ended and then filled with concrete with a reinforcing cage extending about 1/3 of the pile length. The slag fill was from Geneva Steel.

In 2010 during the overpass demolition, Provo River Constructors (PRC) crews assisted BYU with collection of embankment slag and native soil samples along with extraction of 15 to 19-foot lengths of three old piles for testing and closer examination. Soil index, grain-size, and chemical testing were performed on the soil samples. The old slag fill classified as mostly gravel, and the native soil classified as lean clay. X-ray diffraction and scanning electron microprobe analysis were also performed on samples of the old slag and corrosion products to identify key constituents.

Corrosion rates were evaluated on specimens cut from the shell of the longest pile; there was no apparent difference between the three extracted. The pile shell from about 6 to 12 feet deep was encased within a slag crust about 2 to 3 inches thick which was weakly cemented to the pile. Rectangular segments

of the pile were cut, sand blasted, and measured for use in calculating corrosion rate (see Fig. 1).



Fig. 1. Pile segment after sand blasting.

Despite the fact that the old Geneva steel slag would be classified as "corrosive" to steel by FHWA criteria, the relatively low measured corrosion rates for piles in this slag (average of about 8  $\mu\text{m}/\text{year}$  and maximum of 15.6  $\mu\text{m}/\text{year}$ ) were about the same as those obtained in previous studies for piles driven in "non-corrosive" soils along the I-15 corridor in Salt Lake Valley.

Minerals identified in the old slag were primarily Åkermanite with some Vesuvianite. A significant component of the corrosion products was hematite ( $\text{Fe}_3\text{O}_4$ ) or black rust, which, in contrast to red rust ( $\text{Fe}_2\text{O}_3$ ), does not flake upon forming. As a result, black rust provides a protective coating against continued corrosion and may partially explain the relatively low rate of corrosion observed on the piles extracted from the slag.

There was no strong correlation between corrosion rate along the pile and any of the soil properties or chemical concentrations thought to be connected with corrosion. This finding is consistent with many previous studies of corrosion in piles. However, UDOT currently discourages the use of slag next to piles.

For more information, contact Dr. Rollins ([rollinsk@byu.edu](mailto:rollinsk@byu.edu)), Grant Gummow ([ggummow@utah.gov](mailto:ggummow@utah.gov)), or David Stevens ([davidstevens@utah.gov](mailto:davidstevens@utah.gov)).



## Exploring Arizona's Recessed Pavement Markers

Is there a truly plowable reflective pavement marker that can be used successfully on Utah highways to improve wet-night visibility of pavement striping? This question along with success stories from the Arizona DOT (ADOT) brought a group of seven people together from UDOT Region Four, Maintenance Planning, and Research. On September 16, 2013 the group conducted a scan tour to Benson, Arizona to observe some existing projects. Thanks to the organizing efforts of Ken Berg in Maintenance Planning, air transportation from the UDOT Aeronautics Division, and input and driving tours by ADOT engineers, the round trip and scan tour were successfully accomplished in one day.



Recessed pavement markers, I-10 near Benson, AZ

The scan tour objective was to learn first-hand from ADOT what methods they have used to install and maintain recessed pavement markers over the past 15 to 20 years and what level of success they have had with the recessed markers on their plowed highways. Prior to the scan tour, engineers from the ADOT Flagstaff and Safford Districts provided standards and other information to UDOT. Also, several people from UDOT provided questions about ADOT's recessed pavement markers, and these were circulated to a few ADOT engineers for their feedback. The information gathered from the scan tour will be used to help UDOT leaders decide if UDOT will try similar recessed pavement markers in Utah. Information on the scan tour, UDOT's questions and ADOT's answers, and links to relevant documents are available on the applicable [Methods Study web page](#).

While in the Benson, Arizona area, the UDOT group was given a driving tour of various segments of Interstate 10 by ADOT engineers Jackie Watkins and James Hartman, including the Texas Canyon area. The group viewed a few different past and new recessed pavement marker projects on asphalt pavements along the way. Jackie and James, along with others they pulled into a brief question and answer session, were very helpful in answering UDOT's questions during the scan tour.



Recessed pavement marker, I-10 near Benson, AZ

Based on their standards, ADOT uses reflective pavement markers on most of their highways, either in simple raised (no recess) or recessed form. These are spaced 40 feet apart on skip lines and 20 feet apart on inside shoulders of divided highways. They are also used on the centerline of two-way, two-lane highways. Standard markers measure approximately 3.25 inches by 4.5 inches by 11/16 inch high. Where recessed they are placed in grooves 3 to 5 feet long, typically 5 inches wide and 13/16 inch deep at the deepest point. ADOT's policy is to recess the reflective pavement markers in areas where snow plows would damage the markers. Some of the older grooves observed during the ADOT scan tour showed signs of more deterioration than the surrounding pavement. Few missing markers were observed. ADOT has a three to five year cycle for replacement of missing or damaged pavement markers.

UDOT previously used other types of recessed pavement markers in a few locations in the 1990's. Recollections from a few engineers indicate that poor quality of marker installation caused plows to hit and pull out the markers, damaging plows and the pavement. Also, grooves would fill with water, snow, and ice, reducing the effectiveness of the reflective markers and causing additional degradation of surrounding pavement. Use of the recessed pavement markers was discontinued due to the observed disadvantages.

After returning from the ADOT scan tour, the UDOT group has been making plans to try the ADOT-style recessed pavement markers in a few locations in Region Four. Test locations would be evaluated to see if the methods successfully used by ADOT will also work well in Utah. Watch for more information coming from Region Four and Maintenance Planning on the upcoming test locations. (Photo credits: Anne Ogden)

For more information, contact Ken Berg ([kenberg@utah.gov](mailto:kenberg@utah.gov)) or David Stevens ([davidstevens@utah.gov](mailto:davidstevens@utah.gov)).

## More for the Money: Cost-based Estimates are Helping UDOT Design, Advertise and Build More Efficiently

The Utah Department of Transportation is using cost-based estimating as a key part of the project delivery process. Benefits from using a systematic cost-based approach include designs that address constructability and reduce change orders, bid estimates that are closer to actual bids, and a review process to negotiate the best price for change orders during construction.

Traditionally, state governments have used historical averages to estimate project costs. "Most if not all DOTs use historical information, but it's inherently flawed" according to George Lukes, the engineer who manages UDOT's Estimate Support Team. Until 2005, UDOT used historic costs with good success. But when market volatility caused prices to shift quickly historic costs ceased to reflect reality. A look to private sector contractors, who have experience pricing and bidding for projects, offered a way to produce real-world cost estimates.

### Paying it forward through design, bid and construction

Most engineering and design decisions are based on cost, so a reliable cost estimate gives designers the information they need to make informed design choices that result in a high-quality built project. Cost-based estimates build substantial value into project delivery by reducing change orders and other surprises to the contractor and to UDOT throughout the project delivery process.

During design, UDOT's Estimate Support Team produces a reliable fair market value estimate by examining the core constituents of cost-based estimating, including material costs, labor rates and production rates. Other elements, including constructability, accuracy of quantities, risks to contractors, and risks to UDOT are thoroughly examined as well.

Before bids are awarded, cost-estimators review the bids to identify potential risks. During the bidding process, a reliable cost estimate helps UDOT manage funds more effectively. If project costs are overestimated, unused funds are held in reserve and not applied to other projects right away. That money can lose value at the same rate that construction costs climb – an average increase of 8.7 percent recently.

During construction, cost estimators step in on request to

help negotiate the price of change orders. Every overestimated dollar is a dollar lost, so accurate cost estimates are crucial during construction.



During construction, cost estimators step in on request to help negotiate the price of change orders.

### Numbers do the talking

UDOT realized the following savings during Federal Year 2012:

- Improving designs to reduce change orders and risk to UDOT, \$11.4 million
- Conducting bid award reviews to identify potentially costly and risky bids, \$700,000
- Helping construction personnel negotiate fair market costs for change orders, \$800,000

Adding cost-based estimating and contractor experience to the UDOT project delivery process improves design quality and manages costs throughout the life cycle of a project, and delivers projects more efficiently and at a lower cost than using only historical based estimating. The success of using the cost-based process serves as an example of UDOT's innovative spirit and responsible stewardship of public funds.

For more information, contact Catherine Higgins ([chiggins@utah.gov](mailto:chiggins@utah.gov)).



## **Research Calendar of Events/Updates**

### **2013 RESEARCH & INNOVATION POSTER SESSION**

The 2013 UDOT Annual Conference is approaching. The dates for the Conference are November 5-7, 2013. For the third year in a row, the UDOT Research Division will be hosting the Research & Innovation Poster Session in the front of the vendor area of the South Towne Expo Center on November 6 from 9:30 A.M. until 11:30 A.M.

This is a poster session where new transportation engineering ideas, concepts & professional projects are displayed in the main hall. Meet creative minds and discover new approaches to transportation practices. UDOT engineers, consultants, university professors and students will present transportation challenges and solutions in an informal setting.

A few UDOT research projects will also be highlighted by universities and Research Division staff in the Annual Conference breakout sessions.

For more information about the UDOT Annual Conference please click the link: [UDOT Annual Conference](#)

### **RESEARCH FUNDING OPPORTUNITIES** (click to see the full document)

**February 14, 2014** - NCHRP Synthesis of Practice Topics DUE

**March 1, 2014** - NCHRP Highway IDEA Proposals DUE

### **WEBINARS** (click to see the full document)

Title	Day/Date	Time	Location
Pavement Drainage Practices to Achieve Long Lived Pavements (TRB)	Wednesday, Oct. 23	12:00 PM – 1:30 PM	Personal computer or conference room
Beyond Engagement: Key Strategies for Government Leaders	On demand	On demand	
What's on Your Invisible Resume?	On demand	On demand	
Presenting the Perfect Online Presentation	On demand	On demand	